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Prospects of settlement of bison (*Bison bonasus*) from free-ranging populations in Orlovskoye Polesie National Park

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Abstract

Here we summarize the results of long-term work on the formation of large free-ranging populations of the European bison (*Bison bonasus*) in Central Russia (Orel, Kaluga, and Bryansk region). We characterize its dynamic processes and justify the volume of harvest from the population that does not violate population stability. We present the unique experience of bison settlement in other wild populations and provide examples of forecasting population growth with the use of mathematical modeling.

Keywords: European bison, free-ranging population dynamics, growth rate, proportion of withdrawal, settlement, forecasting.

In the expanded list of rare fauna species of Orlovskoye Polesie, the bison (*Bison bonasus*) dominates. It is a symbol of the national movement to rescue rare and endangered species. The work on European bison reintroduction began here in 1996. Within the framework of the Russian Bison Conservation Program (Programma…, 1996), specialists from the A. N. Severtsov Institute of Ecology and Evolution, bison nurseries of Prioksko-errasny and Oka nature reserves, and the WWF of Russia inspected the territory of the national park and adjacent lands. They evaluated the land, climatic conditions and food reserves, carried out radiological measurements, collected data on the veterinary state of the territory and possible limiting factors, including poaching. The results of that research indicated that the territory of Orlovskoye Polesie was suitable for the creation of a free-ranging bison population (Pererva, Sipko, and Kiseleva, 1996). At the same time, the prospects of the growing population of bison beyond the national park — in the forests of Kaluga and Bryansk regions — were also taken into account (Strategiya…, 2002).

In 1996–2001, 65 European bison from various breeding centers of the world were released in Polesie, which concentrated the entire world gene pool of European bison in one population for the first time. For twenty years, the population of bison was characterized by stable positive dynamics. From 1998 to 2016, 367 bison were born here. According to the data of bison registration, the number of yearlings (bison born in 2017) is 40 individuals.

Currently, the national park and adjacent territories of Kaluga and Bryansk regions are home to more than 500 bison. This population of European bison is second only to the Bialowieza population, has a unique genetic potential and has real prospects for further growth (up to 1000 head and more) and for becoming self-supporting. According to experts, the Orel-Bryansk-Kaluga region is a promising location for the preservation of European bison in nature (Prigoryanu, Abadonova, and Karpachev, 2017).

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Table 1. Indicators of the dynamics of the free-ranging population of European bison on the territory of Orlovskoye Polesie National Park

Year	Number of individuals in population	Growth (number of yearlings)	Fertility, %	Death (death toll)	Mortality rate, %
1996	9	0	0	3	33.3
1997	18	0	0	1	5.6
1998	27	1	3.7	0	0
1999	40	3	7.5	1	2.6
2000	57	5	8.8	5	8.8
2001	68	6	8.8	1	1.5
2002	69	1	1.4	0	0
2003	77	8	10.4	2	2.6
2004	80	13	16.3	1	1.3
2005	98	18	18.4	4	4.1
2006	122	24	19.7	4	3.3
2007	141	13	9.2	2	1.4
2008	160	33	20.6	2	1.3
2009	178	33	18.5	6	3.4
2010	208	36	17.3	1	0.5
2011	147	23	15.6	0	0
2012	171	14	8.2	1	0.6
2013	203	32	15.8	5	2.5
2014	237	23	9.7	1	0.4
2015	271	44	16.2	1	0.4
2016	286	37	13.0	1	0.3
2017	350	49	14	1	0.2
2018	383	46	10.4	4	1

The main dynamic indicators of the free-ranging bison population are presented in Table 1. Data on the number of individuals, growth (number of yearlings) and death are taken from the annual records.

Since the bison population is wild, factors such as fertility and mortality are studied in several ways, based on visual observation.

Method 1. Direct observation of bison in the vicinity of feeding grounds in winter. All-Russian counting measures are carried out in this way, which are further recorded.

Method 2. Year-round use of photo-fixing devices (photo traps) at salt licks and feeding grounds.

Method 3. The use of UAVs (unmanned aerial vehicles) — drones and wing drones — to obtain remote data about the population.

Method 4. Bison deaths are logged in the diaries of the inspectors; data are strictly recorded and further transferred to higher supervisory bodies. Due to the large territory of the bison, which includes areas of closed forest stand and other obstructions, information about bison deaths may be incomplete; also, some of the relevance of such recorded events may be lost.

The table shows that the number of individuals is steadily increasing, the birth rate is always much higher than the mortality rate (formula 1), and there are many young individuals in the population; the population is growing.

Fertility and mortality are determined by formulas (1) and (2) (Sashenkova and Ilyina, 2012):

$$\text{Fertility} = \frac{numberoffingerlings}{totalnumber} \times 100\% \qquad (1)$$

$$\text{Mortality rate} = \frac{death\,toll}{totalnumber} \times 100\% \qquad (2)$$

The population growth rate is determined by formula (3):

$$\lambda = \frac{N_1}{N_0}, \qquad (3)$$

where λ is the population growth rate; N_1 is the population density or number at time 1; N_0 is the initial population density or number. So, in 2016–2018 the growth rate of the population amounted to:

$$\lambda_{2016} = \frac{286}{271} = 1.06 \text{ units},$$

$$\lambda_{2017} = \frac{352}{286} = 1.23 \text{ units},$$

$$\lambda_{2018} = \frac{383}{350} = 1.09 \text{ units}.$$

In all three cases, the population growth rate is greater than 1.0, which confirms that the population is growing.

The use of mathematical models allows us not only to predict the state of natural populations, but also (on the basis of calculations of the rate (speed) of growth) to determine the proportion of individuals that can be removed from the population without disturbing the stability of the system. The simplest mathematical formula that can be used for this is:

$$H = \frac{\lambda - 1}{\lambda} \times 100\%,$$

where H is the share of removed individuals, expressed in % and λ is the rate of population growth. It follows

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from this formula that the removal of individuals from the population is possible only if the rate of population growth is greater than one, as, for example, in our case.

In the conditions of Orlovskoye Polesie National Park, possible removal of individuals from the bison population in 2016–2017 was calculated:

$$\acute{I}_{2016} = \frac{1,06-1}{1,06} \times 100\% = 6\% \text{ or17 individuals;}$$

$$\acute{I}_{2017} = \frac{1,23-1}{1,23} \times 100\% = 19\% \text{ or 32 individuals.}$$

Given that only individuals of reproductive age are removed from the population for resettlement purposes, it is impossible to strive to implement these calculated indicators in full. Therefore, in 2014 only four bison (one male and three females) out of 35 were transported from Orlovskoye Polesie to Ugra. In 2015, from the estimated 32 bison that could be removed, only 10 individuals were taken. In 2016, due to the almost snowless winter, as well as small and short frosts, it was possible to carry only seven bison (one male and six females). In 2017 — nine bison (two males, seven females).

According to the recorded count, the number of bison at the beginning of 2018 is 383 individuals. In accordance with this, the projected population growth rate will be:

$$\lambda_{2018} = \frac{383}{350} = 1,09 \text{ units.}$$

At the same time, possible removal of individuals from the bison population in 2018 is:

$$\acute{I}_{2018} = \frac{1,09-1}{1,09} \times 100\% = 8\% \text{ or 31 individuals.}$$

In 2018, 10 bison individuals were planned for resettlement, seven of which were actually sold. Four individuals were moved to Ugra National Park (one male, three females), and three females were moved to Smolenskoye Poozerye National Park.

To predict the further growth of the bison population, we also use two mathematical matrices — the Malthus model of population growth and the Verhulst model of limited growth, followed by a comparative analysis of the data (Table 2).

In the comparative matrix, we chose a required maximum number of 500 individuals. The growth coefficient α is 0.14, based on the number of bison in 2017—350 individuals according to the 2017 count, with 337 at the end of the year, after taking into account all reliable information about death and resettlement during the year.

Table 2. Comparative analysis of the results of the Malthus and Verhulst models

Comparative analysis of the results of the Malthus and Verhulst models			
Data			
N_0=	337		
α=	0.14		
N_{max}=	500		

Time period	Malthus Model	Verhulst Model	Maximum value
2018	387.6422702	351.9910214	500
2019	445.8947468	366.1509227	500
2020	512.9010442	379.4202188	500

At the moment, the real indicators of bison count practically coincide with the forecast data of the models. The Malthus modelshows the greatest similarity to the real situation. Both matrices take into account both birth and death patterns, as well as the needs of the growing bison population for food and spatial resources.

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